Compiler Support for Message Passing Systems
Darpa Contract No. MDA972-97-C-0003

Quarterly R&D Status Report
December 28, 1996 — March 28, 1997

Scientific Computing Associates, Inc.
New Haven, CT

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April 30, 1997

1. Progress During Reporting Period

The work has advanced on two main fronts: gaining more MPI experience and development of our MPI prototype software. The effort in this period conforms to the approach laid out in our proposal for the core project. The work in this quarter primarily addresses objectives *e.4.1, e.4.2,* and *e.4.5* in our work plan.

In addition to the technical work, Dr. Andrew Sherman represented Scientific Computing Associates, Inc. at the Darpa Embeddable Systems Principal Investigators Meeting in Santa Fe, New Mexico in March. He presented a summary of our work at the meeting.

1.1 MPI Experience

We have continued our survey of the MPI literature including two widely read books [1, 2] to gain a better perspective on typical patterns of usage. As part of our testing of the converted MPI prototype software, we implemented a Mandelbrot graphics program that made more extensive use of MPI facilities than our previous test programs.

We also began a dialogue with a number of MPI users in the Darpa community, including Lockheed-Sanders, Concurrent Technologies Corporation, and MIT Lincoln Labs, to better understand the MPI features that are most important to them.

1.2 MPI Prototype

We continued to develop our MPI prototype software, implementing a number of changes in the system. These included:

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1. The object files produced by the system are now standard UNIX object files (.o), rather than the special files used in the past. We accomplished this by encoding the extra information into a text string.

2. We added a significant amount of error checking to the precompiler.

3. We enhanced the runtime system to produce better performance and to simplify the startup and shutdown sequences.

4. We updated the code base for our MPI system to make it consistent with our main Linda/Paradise source tree. (This will help ensure that the parser and certain other compile and link processing modules will evolve as our commercial products do.)

In addition, we began to survey available performance analysis systems so that we will be able to integrate automatic data collection for them in our generated MPI programs.

1.3 Default Communication Contexts

We have implemented a set of defaults for the communication context when there are omitted operands in the _Send and _Recv operations. This eliminates the need for including the near-ubiquitous MPI_COMM_WORLD as the communicator, and as a result, it reduces the code size and improves readability. An example (from the LAM mandelbrot test program):

Original MPI Code:
```
MPI_Recv(result_dim, 4, MPI_INT, MPI_ANY_SOURCE,
         MPI_ANY_TAG, MPI_COMM_WORLD, &status);

source = status.MPI_SOURCE;

MPI_Recv(region, region_dim[0] * region_dim[1], MPI_CHAR,
         source, MPI_ANY_TAG, MPI_COMM_WORLD, &status);
```

New Enhanced MPI Code:
```
source = MPI_ANY_SOURCE;
_Recv@[source](result_dim, region:);
```

The current default policy works well for this example, but may not work as well for codes that make heavier use of a variety of communicators. We will likely revisit these defaults as we gain experience. (We may also want to explore ways in which to allow the programmer to specify the defaults for the system.)

1.4 References

[1] W. Gropp, E. Lusk, and A. Skjellum, *Using MPI: Portable Parallel Programming with the Message-Passing Interface*. Cambridge, MA: The MIT Press, 1994.

2

[2]   P.S. Pacheco, *Parallel Programming with MPI*. Morgan Kaufmann, 1996.

2. Planned Activities and Milestones

We will continue the development of our MPI prototype software, focusing particularly on additional error checking and support for tracing and debugging. By the end of June, we expect to have a usable "beta level" system that we will release for internal applications work and for use by collaborators whom we hope to identify by that time. As noted above, we have begun discussions with several Darpa contractors whom we feel are good candidates to be early users.

We also plan to begin an interaction with Professor Anthony Skjellum of Mississippi State University in regard to the MPI/Real-Time project. We believe that it should be possible to design a system based on our enhanced MPI syntax that will target the proposed MPI/Real-Time semantics in a portable way. At present, there is no adopted standard for MPI/Real-Time, so our discussions will be very preliminary.

Because of the rapid progress we are making on this project, we have begun discussions with Dr. Jose Munoz, the Darpa program manager for this project, about the exercise of the two options associated with the project. Originally, the options were not scheduled until mid 1998, but we believe that we would be in a position to enhance the project's near-term value to the Darpa community if we could have them exercised in the next several months. The main impact of funding the options now would be to make it possible for us to get more heavily involved in testing our technology on applications of significant interest to Darpa. As noted above, we expect to be in a position for such work by the summer.

3. Administrative Information

No significant problems have arisen in this period, and there are no areas of concern. The core portion of the project is ahead of schedule with respect to technical development, and the cost is consistent with the expenditure plan. There were no changes in key personnel during this period, and there were no purchases of major equipment in this period.

Personnel Hours		
	Planned	Actual
Current Period	560	560
Contract Since Inception	833	833

Expenditures in current period: $ 61,233 (inclusive of fee)

Expenditures since inception: $ 89,755 (inclusive of fee)

Total funds committed: $ 374,733

<u>Estimated funds for completion</u>: $ 284,978

    <u>Approximate quarterly breakout</u>:

        $ 45,000 per calendar quarter through 2Q1998.
        $ 60,000 in 3Q1998,
        $ 16,211 in 4Q1998.

<u>Estimated date of completion</u>: October 15, 1998